



Deep Impact's Comet on a Stick! Educator Page



Created for the Deep Impact Mission, A NASA Discovery Mission
Maura Rountree-Brown and Art Hammon
Educator - Enrichment

The "Comet on a Stick" activity can be used with a wide age range. All students will see that modeling is continuous on a NASA mission as is evaluation of those models. Younger students will learn the basic characteristics of a comet. Older students will practice evaluation and improvement of the comet model shown. The importance of this activity is not the initial model or its exercise, but the fact that it will put students in the position of emulating a process scientists and engineers follow on all missions.

The activity:

"Comet on a Stick" - The activity

"The Deep Impact Paper Comet" - A less expensive version of the "Comet on a Stick for wider use"

Supplies are shown on each activity. Gather household and art supplies so that students can improve or build new models.

Background materials for this activity:

Consider This - This page shows the history of perceptions about comets.

A Comet's Place in the Solar System - A little history about where comets came from

Ten Important Comet Facts - A quick review of comet facts

C-O-M-E-T-S - A comet acrostic. Good for younger students or comet quick fact reference

Deep Impact - Interesting Mission Facts - Some fun facts about the Deep Impact mission

Small Bodies Missions - Learn more about Deep Impact and about other missions to comets and asteroids.

National Science Education Standards related to this activity:

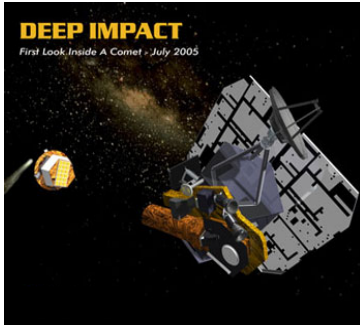
Science as Inquiry:

- ☐ - Identify questions that can be answered through scientific investigations
- ☐ - Think critically and logically to make the relationships between evidence explanations
- ☐ - Develop descriptions, explanations, predictions and models using evidence
- ☐ - Recognize and analyze alternative explanations and predictions

Tips for materials to improve or build comet models:

- ☐ - Find fruits and vegetables that might look like a comet nucleus.
- ☐ - Get different "surface" coverings like chocolate cake mix or icing, chocolate shell (you'll need to freeze the object you cover)
- ☐ - Paper or streamer of different kinds
- ☐ - Paints or other coloring solutions
- ☐ - Any kind of textured covering that you think would be useful
- ☐ - Netting or other shear fabrics
- ☐ - Bulk cushion stuffing fiber or cotton balls
- ☐ - Tin foil
- ☐ - See what else you can come up with

Questions: Maura Rountree-Brown at Maura.Rountree-Brown@jpl.nasa.gov



Deep Impact Comet Modeling



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Modeling is an important part of any space mission and begins earlier than most people think. Before any piece of hardware is built or software is designed, in fact, before anyone begins to make calculations for the size and shape of the spacecraft, intensive research must be done and certain questions must be asked.

- ☐ - What do we want to find out?
- ☐ - Where should we go in space to find this information?
- ☐ - In the case of the Deep Impact mission, what do we know about Comet Tempel 1?

Obviously, it isn't possible to visit Tempel 1 to get all the information we need in order to design a mission so scientists and engineers perform exercises to "model" our comet. They ask themselves questions like:

- ☐ - What other comets do we have information on?
- ☐ - What has that information told us?
- ☐ - If we build a model for a comet we know better, will it tell us what we need to know about the one we will visit?

The Deep Impact mission has used Giotto's images of Halley's comet as well as the more recently collected images of DS1's views of the comet Borrelly. Using what we know about those comets, and combining that information with images of Comet Tempel 1 taken from Earth, the Deep Impact team has created models for researching the following challenges:

- ☐ - How fast is Tempel 1 rotating and is it slow enough to allow us to see the crater we make?
- ☐ - When sunlight falls unevenly on the comet, can we design software that will help our impactor find the best lit area to target?
- ☐ - Based on what we know about cometary dust environments, will our impactor and spacecraft arrive safely to impact? How large a dust particle can the twin spacecraft survive before the images they are collecting are blurred or the spacecraft themselves are damaged?

Questions for your students: If you were building a model of a comet out of odds and ends ☐ around the house, what fact about a comet would you choose to show and what materials would you find to build it? If you were designing a mission, how would you use your comet model to test some of your challenges and bring them to solutions?



"Deep Impact Comet on a Stick"



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Student - Inquiry

Purpose:

Develop a model of a comet and use the same thought processes as a science and engineering team do to design and build missions. Use it to test your theories about comets and then evaluate the strengths and weaknesses of your comet model. The importance of the activity is not the initial model, but the model your students improve or design and their evaluation of the initial model.

Project:

The **Deep Impact** mission will launch in 2004 and encounter Comet Tempel 1 on July 4th of 2005. The **Stardust** mission is in space right now and headed toward Comet Wild (pronounced Vilt) 2. Before these missions launch, scientists and engineers use modeling to research and test some of their theories about comets. They also use modeling to find solutions to some of their mission challenges. Modeling takes place throughout the life of a mission as challenges arise. You can try modeling by making a "Comet on a Stick". Use it to test the influence of the Sun on these small bodies. Discuss as a class some theories about comets. Then try to communicate them with the stick comet. This is a good model for some of the attributes of a comet. For others, it is not. Can you figure out which are the strengths and weaknesses for this model? Can you improve the stick comet model? Can you design your own model to communicate what you know or need to know if you are going to design a mission to a comet? If you need to know more about comets, visit <http://deepimpact.jpl.nasa.gov> and <http://stardust.jpl.nasa.gov> to learn more about the Deep Impact Stardust missions.

Before you start:

As a class, discuss what you know about comets. Build one list. Add to that list the things you wonder about comets or don't know. Now you want to build a model to study one question: If you have to send a spacecraft to a comet, what will you need to consider about the way the Sun affects a comet? Now, build your "Comet on a Stick".

Materials:

One 2" styrofoam or other ball	Two 1 – 2 ft lengths of mylar gift strips
One 5" strip of tape	One wooden skewer (shish kabob type)
An electric hairdryer/electrical power available	One marker pen
You or your students gather household or art supplies for students to use to design their own comet models.	

Directions:

1. Make a tiny hole in the ball so it can be mounted on the skewer (the fit of the skewer should be tight). Mount the ball on the skewer.
2. Place the mylar strips on top of the ball so the two pieces cross each other in an "X" and the lengths of all sides of the strips hang down evenly. You can also use light ribbon.
3. Attach the strips to the ball with the 5" strip of tape or narrow masking tape wrapped over the strips and around the circumference of the ball.
4. With a marker pen, assign a "front" for your comet and represent it with the letter "H" for head. On the opposite side, mark the letter "T" for tail of the comet.

Here's what you do:

Use a hairdryer to simulate a portion of the Sun's solar energy as it meets the comet. The heat from the Sun causes gas, ice, particles and rocky debris of various sizes to burst from the comet (called coma) and the solar wind causes these substances to form a "tail" behind the comet. Have someone be the "Sun" and stand in place with the hairdryer. The hairdryer simulates the solar wind causing the comet tail (mylar strips) to form and trail behind the comet. Aim the hairdryer at the comet as it approaches and as it moves away. The "Sun" will have to turn in place to keep the "solar wind" flowing to the comet. You hold the comet by the stick and walk in an elliptical orbit around the Sun. As the comet gets closer to the Sun, the solar heating and solar wind affects the comet so that the tail forms and so that it stays in opposition to the Sun. As it travels away, the lost solar heating of the Sun causes the tail to diminish.

Questions: Use the materials you gathered to have students improve or build new models.

1. How does this model succeed in showing the influence of the Sun on a comet?
2. How is this model unsuccessful at showing the proper influence of the Sun?
3. What other elements of a comet can be seen using this model?
4. Which elements of a comet are not well shown by this model?
5. Can you improve the model by changing it or making an entirely new model?
6. The Stardust mission takes a comet sample by flying near the front of Comet Wild 2 instead of the trailing tail. Why? Can you model the reason for their decision?
7. The Deep Impact mission makes a crater in the nucleus of Comet Tempel 1 with a copper projectile. A sister spacecraft nearby takes optical and spectrometer data during the encounter and for 14 minutes after impact. What do they need to consider about a comet in order to successfully gather their data?
8. Form teams and choose three facts about comets you would like to show through modeling. Make a new model or improve your ping-pong comet.
9. As a team decide what kind of comet mission you would design. Take one of the challenges you will face and try to create a model that will help you work the challenge to a solution.

Tips for the Teacher:

1. A hairdryer only sends "wind" from one side while the Sun would be sending out solar wind from all sides.
2. This model does form a tail with the solar wind but it fails to show that the material that outgases from the comet mostly shoots forward. This is why we see the front of the comet glow but do not directly see the nucleus of the comet which is hidden further back inside the comet's coma.
3. The Stardust mission will not take its sample from the tail behind the comet because there is a much higher concentration (density) of material on the sunward side where it originates. By the time it blows back into the tail, it is very spread out. Similarly, the Deep Impact observing spacecraft must maintain a path beneath the comet, which passes overhead. This helps the spacecraft to avoid coma debris from the comet tail and safely transfer its images and other data to Earth through the Deep Space Network antennas.
4. This model does not show that the tail of a comet appears curved because in space we see a "history of the tail". At any point in time, particles move directly away from the Sun (as in this model). Over time, as the comet curves around the Sun on its orbit path, the particles leave a tail that is curved (not shown in this model).
5. As the comet moves away from the Sun, the model tail droops. In space, the particles and debris continue to be swept away from the nucleus, but the production rate of debris decreases.
6. Comets are not white since the rock and debris being outgassed clings to the surface of the comet in a crust that is blacker than toner for a copy machine. Comets also appear in different irregular shapes and are not round "balls". They are shaped more like potatoes. Scientists are not sure how rough or smooth the surface of a comet might be and will get that information from the missions currently planned by NASA.
7. Comets have three tails: the largest is the dust tail produced by radiation light pressure from the Sun. The ion tail, produced by "solar wind" and a neutral sodium tail produced by solar wind.



Paper Comet Model with a Deep Impact

An option to the "Comet on a Stick"



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Student - Inquiry

Purpose:

Develop a model of a comet and use the same thought processes as a science and engineering team do to design and build a mission. Use it to test your theories about comets and then evaluate the strengths and weaknesses of your comet model. The Paper Comet is an option to the "Comet on a Stick". The value of this activity is not in the original model but in the evaluation and changes your students make to it.

Project:

The **Deep Impact** mission will launch in 2004 and encounter Comet Tempel 1 on July 4th of 2005. The **Stardust** mission is in space right now and headed toward Comet Wild (pronounced Vilt) 2. Before these missions launch, scientists and engineers use modeling to research and test some of their theories about comets. They also use modeling to find solutions to some of their mission challenges. Modeling can and often does take place throughout the life of a mission. You can try modeling by making a paper comet and considering the influence of the Sun on these small bodies. Discuss as a class some theories about comets. Then try to communicate them with the paper comet. This is a good model for some of the attributes of a comet. For others, it is not. Can you figure out which are the strengths and weaknesses for this model? Can you improve the paper model? Can you design your own model to communicate what you know or need to know if you are going to design a mission to a comet? If you need to know more about comets, visit <http://deepimpact.jpl.nasa.gov> and <http://stardust.jpl.nasa.gov> to learn more about the Deep Impact and Stardust missions.

Before you start:

As a class, discuss what you know about comets. Build one list. Add to that list the things you wonder about comets or don't know. Now you want to build a model to study one question: If you have to send a spacecraft to a comet, what will you need to consider about the way the Sun affects a comet? Now, build your paper comet.

Materials:

One 8 ½ X 11 sheet of paper	Two 1 – 2 ft lengths of mylar gift strips
One 2" strip of tape	One non-bending drinking straw
An electric hairdryer/electrical power available	One marker pen

You or your students gather household or art supplies so that the students can improve/build new models.

Directions:

1. Cut or tear the corners of your sheet of paper to within 3 inches of the center of the page.
2. Place the mylar strips evenly one across each paper slit so they form an X on the paper.
3. Crumple the paper into the shape you think best represents a comet and make sure that your strips of mylar stay to the outside of your paper and can fly like streamers.
4. Decide a "front" for your comet and represent it with the letter "H" for head. On the opposite side, mark the letter "T" for tail of the comet.

Here's what you do:

Use a hairdryer to simulate a portion of the Sun's solar wind as it meets the comet. The heat from the Sun causes gas, ice, particles and rocky debris of various sizes to burst from the comet (called coma) and the solar wind causes these substances to form a "tail" behind the comet. Have someone be the "Sun" and stand in place with the hairdryer. The hairdryer simulates the solar wind causing the comet tail (mylar) to form and trail behind the comet. Aim the hairdryer at the comet as it approaches and as it moves away. The "Sun" will have to turn in place to keep the "solar wind" flowing to the comet. You hold the comet by the straw and walk in an elliptical orbit around the Sun. As the comet gets closer to the Sun, the solar heating and solar wind affects the comet so that the tail forms and so that it stays in opposition to the Sun. As it travels away, the lost solar heating of the Sun causes the tail to diminish.

Questions: Use the materials you gathered to have the students improve or build new models.

1. How does this model succeed in showing the influence of the Sun on a comet?
2. How is this model unsuccessful at showing the proper influence of the Sun?
3. What other elements of a comet can be seen using this model?
4. Which elements of a comet are not well shown by this model?
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6. The Stardust mission takes a comet sample by flying near the front of Comet Wild 2 instead of the trailing tail. Why? Can you model the reason for their decision?
7. The Deep Impact mission makes a crater in the nucleus of Comet Tempel 1 with a copper projectile. A sister spacecraft nearby takes optical and spectrometer data during the encounter and for 14 minutes after impact. What do they need to consider about a comet in order to successfully gather their data?
8. Form teams and choose three facts about comets you would like to show through modeling. Make a new model or improve your paper comet.
9. As a team, decide what kind of comet model you would design. Take one of the challenges you will face and create a model that will help you find a solution to the challenge.

Tips for the Teacher:

1. A hairdryer only sends "wind" from one side while the Sun would be sending out solar wind from all sides.
2. This model does form a tail with the solar wind but it fails to show that the material that outgases from the comet also shoots forward. This is why we see the front of the comet glow but do not directly see the nucleus of the comet which is hidden further back inside the comet's coma.
3. The Stardust mission will not take its sample from the tail behind the comet because there is a much higher concentration (density) of material on the sunward side where it originates. By the time it blows back into the tail, it is very spread out. Similarly, the Deep Impact mission must avoid coma debris from the tail until the data is safely transferred from the sister spacecraft to Earth through the Deep Space Network antennas.
4. This model does not show that the tail of a comet appears curved because in space we see a "history of the tail". At any point in time, particles move directly away from the Sun (as in this model). Over time, as the comet curves around the Sun on its orbit path, the particles leave a tail that is curved (not shown in this model).
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Questions? Contact: Maura.Rountree-Brown@jpl.nasa.gov



Comet Models

Based on the Deep Impact Mission



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Educator/Student - Inquiry

Here are some comet models you can try to build. Then design your own model. You can also use these models to explore some of the facts and concepts about comet science.

Comets have a dark surface we can't see through. From what is it made?

Make several ice cream balls or use baking potatoes and cover them with different materials:

- Is it a hard crust? – Use chocolate shell. (hardens into a layer)
- Is it a slushy crust? – Use chocolate syrup
- Is it powdery – Use cocoa powder or cake mix
- Is it rough and thick – Use broken cookies

Cover the surface of your “comet” so that the inner contents can't be observed. (The Deep Impact Mission will visually observe how the impact is made to the surface of the crust to learn more about its makeup.) Try to have another team design an experiment to see what is beneath the surface of your comet? Which kind of surface do you think we will find on a comet and why?

What do you think we will find beneath the surface of a comet?

Look for a candy bar that you believe might show what it is like under the surface of a comet. Is it a dark or light? Is it smooth or full of “debris” – peanuts, candy etc? Are there layers beneath the surface or not, and is it a delicate or sturdy in formation? Why do you think you have picked a good model?

How will you build and evaluate your own model?

Have the class bring materials from home and have teams decide on a mission design, comet theory or comet question they would like to communicate. Have them design a model to communicate their question about a comet. Have them build it and design a test to try to confirm their theory or answer their question. Was it a good model and can they improve it? If there is time, work on an improved designed based on evaluation of the first model.